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Design characteristics unique to the flexographic printing process

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**Design Characteristics Unique to the
Flexographic Printing Process**

By
Barry Allen Lee

Submitted to the
Department of Packaging Science
College of Applied Science and Technology
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE

Rochester Institute of Technology
1998

Design Characteristics Unique to the Flexographic
Printing Process

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Abstract

The flexographic printing process has been used for package printing applications since the late 1800's. Recent improvements in the flexographic technology have enabled flexographic printers to compete in new market areas that have historically been served by roto-gravure or offset lithographic printing. Occurring simultaneously with the flexographic printing improvements has been the infusion of personal computer-based graphic design capabilities. Designers can optimize quality only when they understand the strengths and weaknesses of the printing process that will be used to mass produce their design. Desktop design capabilities and the need for flexographic print quality to match or exceed lithographic and roto-gravure print quality are both factors that accentuate the need to understand the process in an effort to create a design that will be of high quality when printed flexographically. Designing package graphics for the flexographic process is unique for a number of reasons, (the "master image carrier" (printing plate) is significantly different from roto-gravure and offset lithography, the inks used in flexography are significantly different from those used in gravure) and a wider assortment of substrates may be printed by the flexographic process than by the offset lithographic process. Each substrate has its own printing characteristics. This thesis will inform those who may be interested in designing for flexographic printing of the unique considerations that should be addressed when designing a package graphic for flexographic printing. Considerations specifically addressed are; variable repeat length capabilities, reverse-side printing, trapping, typography halftones and dot-gain screen ruling and substrate, step-and-repeat and flexographic plate elongation.

Table of Contents

Abstract	v
Chapter One: Background Information and Problem Statement	1
Chapter Two: Traditional Printing Processes	5
Chapter Three: Flexographic Technology	9
Two Roll with Doctor Blade and Dual Doctor Ink Chamber System	10
Anilox Cells	13
Plate Cylinders and Repeat Length	14
Press Configurations	15
Multi-Color Capabilities	18
Reverse-Side Printing	18
Flexographic Plates	19
Plate Mounting Systems	22
Chapter Four: Substrates and Substrate Influence on Flexographic Printing	26
Chapter Five: Flexographic Design Considerations	32
Trapping	32
Typography	34
Plate Distortion and Elongation	36
Halftones and Screening	38
Dot Gain	39
Highlights and Vignettes	40
Dot Shapes	41
Screen Ruling and Substrate	41
Screen Angles	41
Stochastic Screening	42
Step and Repeat	42
Diecutting and Converting	44
Prepress Output	45
Proofing	47
Chapter Six: Summary and Conclusions	50
Appendix	53
Glossary	58

Chapter 1

Background Information and Problem Statement

The chances are great that a typical consumer will come into visual or direct physical contact with material printed by the flexographic process on a daily basis. The odds are also high that purchasing habits are often influenced by flexographic package printing. Often, it is the product that gains a reputation, but it is the package which identifies the product. "Psychologically, the printed design reflects the personality of the product and the philosophy and taste of the firm that made it."¹

Packaging graphics are the last and possibly the most important advertising many products receive. Flexographic printing technology is used on a wide variety of materials for a greater variety of packaging applications. Arguably, it is the flexographic process "flexibility" that is its greatest advantage. Soft compressible printing plates, fast drying fluid inks, and a simple efficient ink delivery system give the flexographic printer the ability to reproduce high quality graphics on many different surfaces.

During the last decade, the dollar volume of products produced by the use of the flexographic printing process has been growing at a rate of approximately eight percent a year, a rate unparalleled by any other printing technology. Some of this growth is due to the increased need for packaging and packaging graphics. However, another source of new business for flexography is products that have traditionally

been printed by the other major printing processes— gravure and offset lithography. Print buyers are beginning to recognize flexography as an economical, high quality alternative to gravure and lithographic printing.

Packaging buyers have begun to hold the flexographic printer to the same high quality standards as lithography and roto-gravure. This fact means that the flexographic printers will have to consistently deliver high quality graphics. Specifically tone reproduction is expected to be the same resolution in flexography as that printed by lithography and gravure. Historically, the flexographic printing process has been used for low cost/low quality packaging graphics. In fact, the stigma of being a “cheap” printing process has caused some packaging buyers to ignore flexography when selecting a process for higher quality graphics. Even within the industry a culture shift from low cost/ low quality to low cost /high quality has been slow to come about. Many flexographic printers find themselves with the newest high tech equipment and materials, but stuck at the beginning of a “relearning” curve.

Adding to the problems flexographers find when competing with other printing processes is the fact that there are no established standards for flexographic printing. Some standards that may be helpful include trapping, dot gain, and specific values for process color inks. The fact that the flexographic industry is without these standards complicates communication between buyers, suppliers, and printers, and makes quality consistency very difficult.

The recent move to "desktop" design has also introduced new problems for flexographic printers. With the use of the computer it has become relatively simple for the novice to create attractive new package designs. Unfortunately, many of the novice designers are ignorant of the limitations of the printing technology that will be used to mass produce their designs. Also many designs that appear attractive on a computer monitor are impossible to reproduce on a flexographic printing press due to press registration problems and ink limitations.

When a designer who has experience creating a package design to be printed by offset lithography or gravure applies the same design principles for a flexographically printed graphic, they may be creating problems for the flexo printer. "Without the benefit of research into production methods and equipment, an otherwise simple design for gravure or offset would pose many printing problems for flexo."²

Endnotes for Chapter 1

1. Veronica Michalowski. *Flexography: Principles and Practices*
Foundation of Flexographic Technical Association,
Ronkonkoma. 1991. p 33.
2. Ibid. p 37.

Chapter 2

Traditional Printing Processes

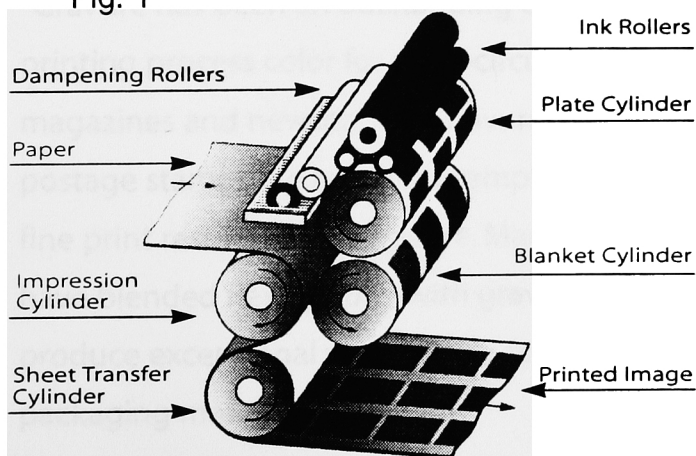
The three most commonly used printing processes are lithography, flexography, and gravure. Each of these processes has its own inherent advantages and disadvantages. To better understand the primary differences in each process, one needs to compare three key areas: the ink, the ink delivery system and the image carrier.

The most often used printing process (number of printing presses currently in production) is lithography, sometimes called offset lithography. Lithography is used heavily in the publication industry for printing magazines, catalogs, and many daily newspapers as well as a number of other applications like annual reports, advertising, and art reproduction. Lithography is also often used for packaging such as folding cartons, labels, and bags. .

Offset lithography is classified as a “planographic” process. That means the printing plate or *image carrier* used for lithographic printing holds both the image and non-image on one flat surface or plane. The image areas of a lithographic plate are chemically treated to be attractive to the lithographic paste ink, while a fountain solution or ink repellent chemical treatment protects non-image areas from inking.

In a lithographic printing press, a paste ink is applied to the image areas on the plate,

Fig. 1



the image is then transferred to a blanket (hence the term offset), and then to the substrate.

“Lithography has been a favored process because it can reproduce soft tonal values on coated substrates. Another highly prized feature of lithography is its ability

Gravure, sometimes known as roto-gravure, is the second most often used process in Europe and the Far East, and the third most often used process in the US. The gravure process prints perhaps the widest variety of products of all processes. Gravure is also heavily used in the magazine printing industries and also prints many of the inserts in the Sunday newspaper. Vinyl flooring and woodgrain desktops and paneling are also printed by gravure. An off-set gravure process is used to print the M on the M&M candy, and the printing on many medicine capsules. Gravure is also used for many of the same packaging applications as those of the flexographic process.

The gravure printing process is classified as an "intaglio" process. An intaglio printing process recesses the image below the level of the non-image areas. A gravure image is etched or engraved into a copper plate or copper plated cylinder. All gravure images are etched in a cell format on the gravure cylinder. By varying the size and depth of each cell, the gravure press can vary tones. Often, after the copper is etched or engraved, the plate or cylinder is plated with chrome to add durability and run-length to the gravure cylinder.

In a gravure press, a fast drying fluid ink fills the recessed cells, a thin metal strip called a doctor blade clears the non-image area of ink, and then the image is transferred directly to the substrate under heavy impression pressure from a rubber covered impression roll.

"Gravure has been an outstanding choice for printing process color for mass-circulation magazines and newspapers. Gravure-printed postage stamps are another example of the fine print results of roto-gravure. Many plants have blended flexography with gravure to produce exceptional print results on packaging materials."²

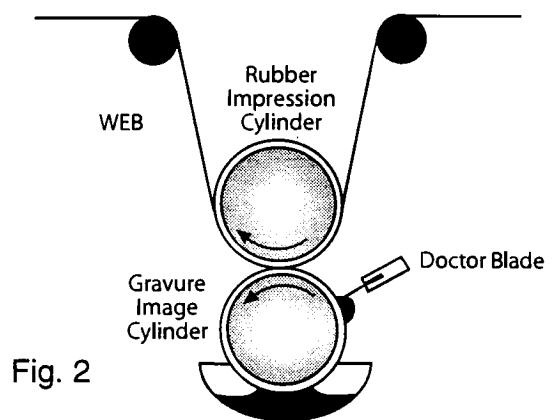


Fig. 2

The flexographic printing process is classified as a relief process. A relief printing process is characterized by the image areas being raised above the surrounding non-image areas. Letterpress is also a relief printing process, the primary differences between letterpress and flexographic printing technologies are: 1. Plate hardness — the letterpress plate is hard and non-compressible, the flexographic plate is relatively soft and compressible; 2. Ink — the letterpress ink is a paste consistency, the flexographic ink is a fluid, about the same consistency as paint.

In a flexographic press, an ink metering roll called an anilox, is brought into light contact with the raised image areas of the flexographic plate by an adjustment controlled by the flexographic press operator. The flexographic press operator then moves the plate into light contact with the substrate to cause image transfer.

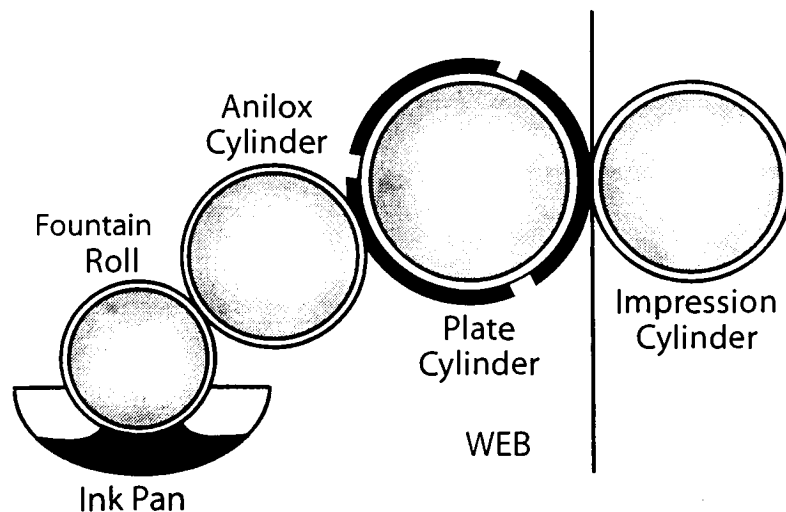


Fig. 3

Table 1

	FLEXOGRAPHY¹	GRAVURE²	OFFSET LITHOGRAPHY²
Substrates	Wide variety, can print on most packaging materials	Wide variety, can print on most packaging materials	Limited, not easily adapted to films or laminated packaging materials including polyethylene, paper, foils, and laminates
Impression Pressure	Light "kiss" impression pressure	Heavy pressure in printing nip	Relatively high pressure in printing nip
Plate life/Run length	Avg. plate life between 1-2 million impressions	Avg. cylinder life between 3-4 million	Avg. plate life between short and long run available up to 300,00
Press Size	Many web widths available widths range from 6" to 90" (wider for corrugated)	Many web widths available widths range from 2" to 110" (wider for vinyl flooring)	Standard format size sheetfed up to 60" web 11"-60"
Cut-off Repeat length	Variable repeat	Variable repeat	Standard format/fixed cut-off
Speed	Product dependent eg. toilet tissue-3,000 fpm; bread bags-5000-9000fpm	Product dependent publication-3,000fpm vinyl flooring-50fpm	Product dependent sheetfed 12,000 imp/hr 2500 fpm Pressure sensitive labels-150-300fpm
Ink	Fast drying fluid ink solvent, water, and UV curable dry trapping	Fast drying fluid ink solvent, water dry trapping	Heat-set and non heat-set paste ink wet trapping
Digital Imaging	Laser engraving and laser exposable (new) available	Heavily utilized	Yes, on press and off press available

1. Veronica Michalowski. *Flexography: Principles and Practices*
 Foundation of Flexographic Technical Association,
 Ronkonkoma. 1991

2. *Gravure Process and Technology*

Chapter 3

Flexographic Technology

Flexographic printing units in use today are simple in design and easy to understand.

The following components make-up a flexographic printing unit:

- Fountain Roll
- Anilox Roll
- Doctor Blade
- Dual Doctor Ink Chamber
- Plate Cylinder
- Impression Roll

There are three types of flexographic printing units being used today: two roll (fig. 3), two roll with doctor blade (fig. 4), and dual doctor chambered systems (fig 5). The two roll units are usually found on older flexo presses, and on narrow web presses. Narrow web presses doing process color work will probably be equipped with two roll and doctor blade, and more modern wide-web presses are equipped with the dual doctored chambered system. Each of these printing units may preform acceptably, however, a doctor blade system should be used when doing screens and process color flexographic printing.

To understand each type of these printing units, it is important to first understand the “heart” of the unit, the anilox roll. The surface of every anilox roll has been engraved with a tiny cell pattern, cells so small they can only be seen under magnification. The size and number of these cells determines how much ink will be delivered to the image areas of the flexographic plate, and then to the substrate. An anilox roll is either copper engraved and then chrome plated, or ceramic coated steel with a laser engraved cell surface.

Two Roll with Doctor Blade

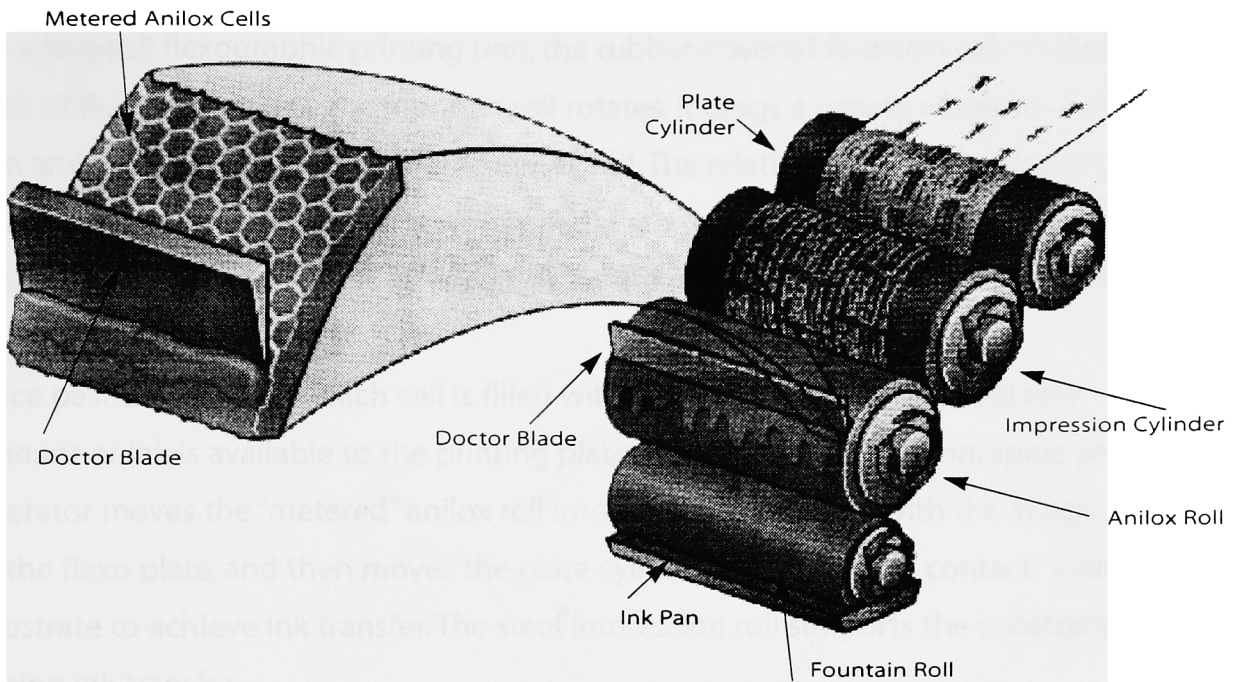


Fig. 4

Dual Doctor Ink Cylinder System

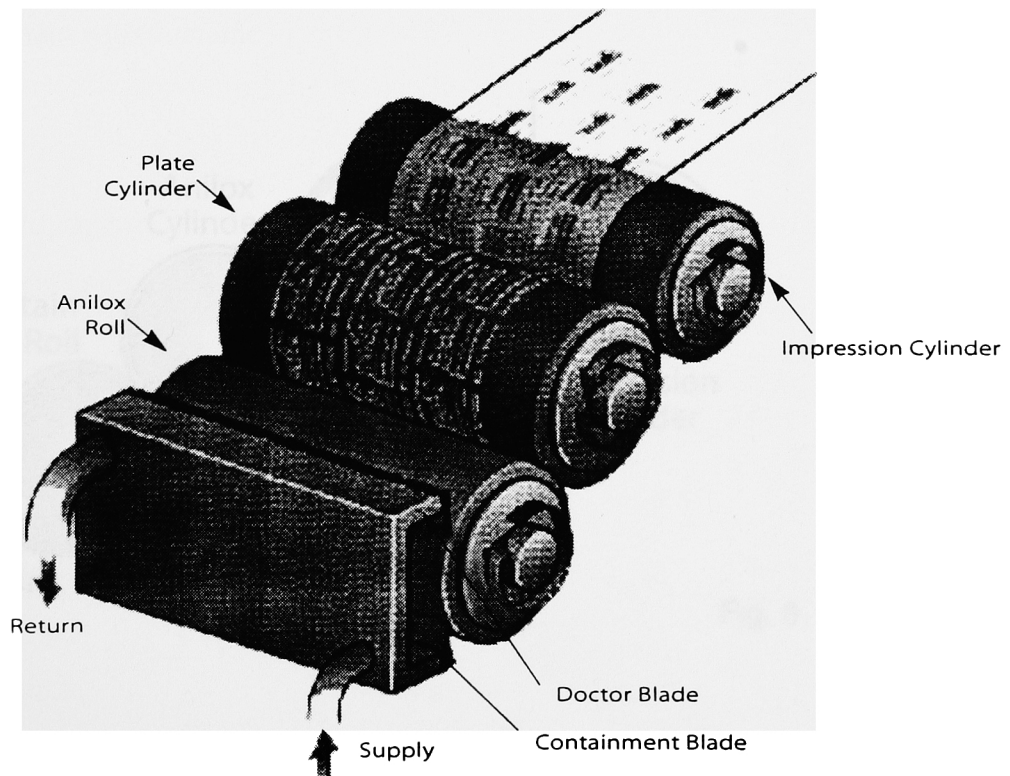


Fig. 5

On a two-roll flexographic printing unit, the rubber-covered fountain roll rotates in a bath of fluid flexo ink. As the fountain roll rotates, it drags a supply of ink from the ink pan and delivers it to the cells of the anilox roll. The relatively soft, rubber-covered fountain roll is held in tight contact (nipped) with the anilox roll. As the anilox rotates past the nip point, excess ink is "wiped" from the non-cell area by the fountain roll. As the anilox rotates past the nip point, excess ink is "wiped" from the non-cell area by the fountain roll.

Once past the nip point, each cell is filled with ink, and a measured, repeatable amount of ink is available to the printing plate. On the press, the flexographic press operator moves the "metered" anilox roll into light "kiss contact" with the image areas of the flexo plate, and then moves the plate cylinder into light "kiss contact" with the substrate to achieve ink transfer. The steel impression roll supports the substrate during ink transfer.

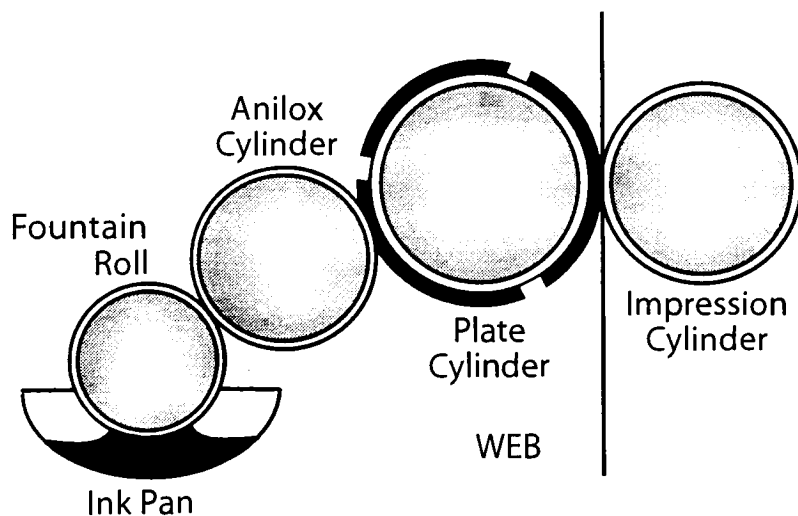


Fig. 6

When a doctor blade is used with a two-roll unit, the nip between fountain and anilox roll is opened to allow the ink to flood the anilox and fill the cells. The doctor blade, a thin metal or polyethylene blade then comes into contact with the anilox to sheer excess ink from the non-cell areas.

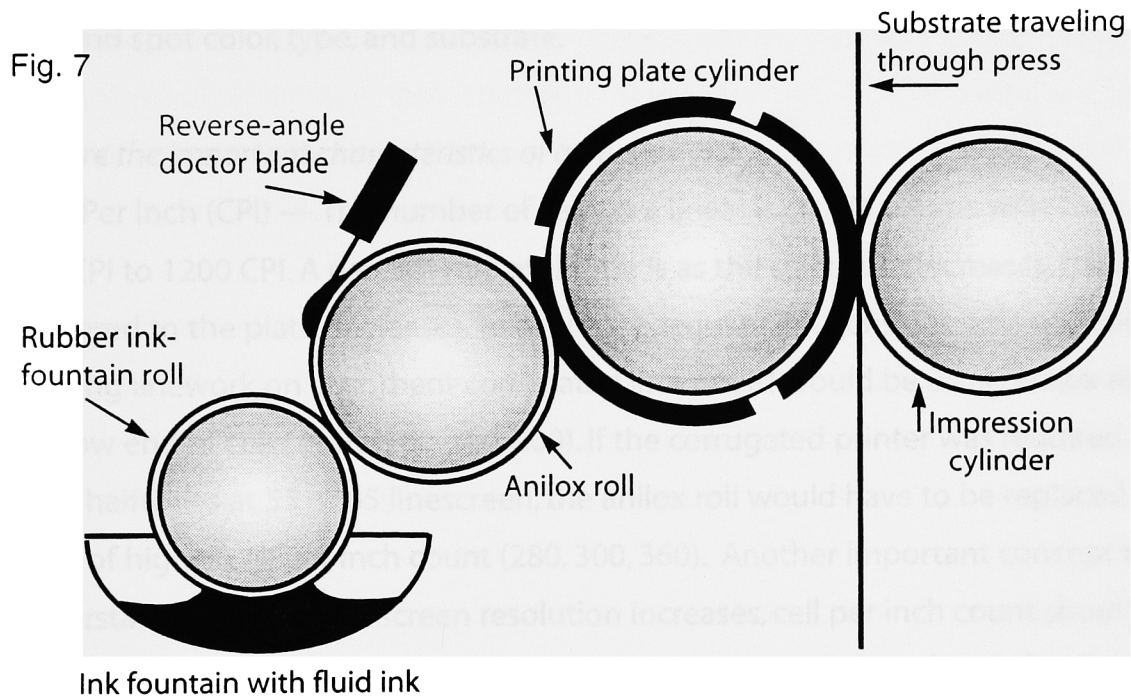
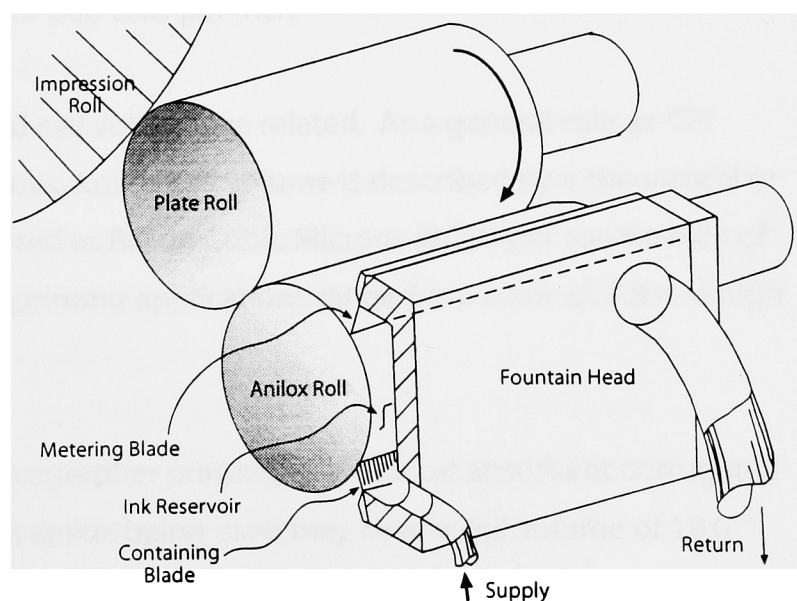


Fig. 8

When the flexographic press is equipped with chambered doctor blade inking units, the fountain roll and inking pan can be eliminated, and ink is delivered directly to the anilox through an enclosed chamber.



Anilox Cells

The best flexographic printers select anilox rolls for their press after carefully evaluating the type of printing they intend to do, and the type of substrate they will be printing on. Often the flexographic printer will perform test runs to determine the ideal type of anilox in an effort to maximize graphic elements related to screen ruling, solids and spot color, type, and substrate.

These are the important characteristics of an anilox roll:

- **Cells Per Inch (CPI)** — The number of cells in a linear inch. CPI counts will range from 140 CPI to 1200 CPI. A general rule of thumb is as the cell count increases, the ink delivered to the plate decreases. To achieve adequate ink densities, a flexographer printing linework on absorbent corrugated linerboard would be using anilox rolls at the low end of cell count (160, 180, 200). If the corrugated printer was required to print halftones at 55 or 65 linescreen, the anilox roll would have to be replaced with a roll of higher cell per inch count (280, 300, 360). Another important concept to understand is that as line screen resolution increases, cell per inch count should also increase. For instance, a process color graphic on a polyethylene frozen food bag may be printed at 133lpi. For best results, and in order to avoid "flooding" the halftone dots with ink, the cell count of the anilox roll that inks the 133lpi printing plate should be at least 550 or 600 cells per inch
- **Cell Volume** — Cell count and cell volume are related. As a general rule, as CPI increases, cell volume decreases. Anilox cell volume is described by a theoretical or measured volume, and reported as Billion Cubic Microns (BCM) per square inch of cells. Typical BCM ratings for printing applications range from a low of 1.8 to a high of 14.

Using our example of the flexographer printing linework on absorbent corrugated linerboard, the low cell count anilox being used may have a cell volume of 10.0

BCM, and the process color on polyethylene at 133lpi, and a 600 linescreen plate may be inking with an anilox cell volume of 2.8 BCM.

- **Cell Angle** — Anilox cells are engraved in a linear pattern, and at various angles. Typical anilox cell angles are 30°, 45°, and 60°. It is important to understand that the screen angle of the printing plate and the cell angle of the anilox roll can combine to cause an objectionable moiré pattern, even if only one color halftones are being printed. Many anilox roll suppliers produce a random cell (no-angle) anilox that may be used for limited applications.

While an anilox cell angle may be selected to help avoid moiré, the problem of moiré is usually avoided by angling the separation screens. Research and experience has shown that the 60° angle allows for more complete ink transfer, and is becoming the preferred cell angle for flexographic printers.

There is currently no other single component of the flexographic process that will have as significant an effect on flexographic print quality as the type of anilox roll being used.

Plate Cylinders and Repeat Length

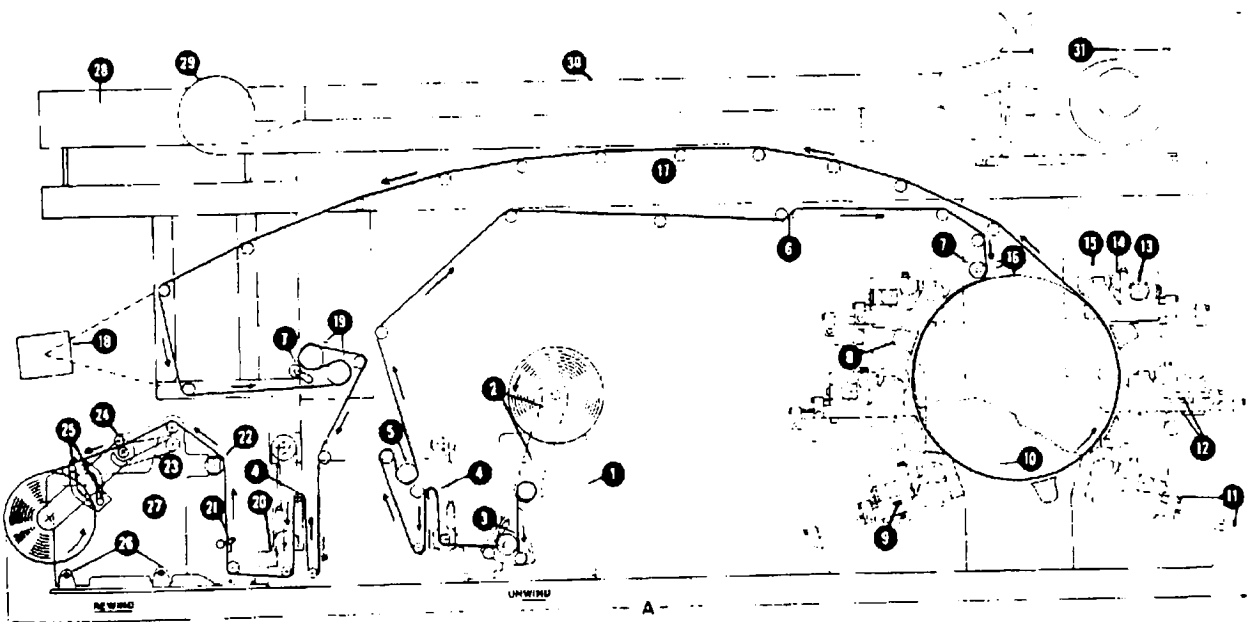
All flexographic presses, with the exception of corrugated and newspapers have a variable repeat length capability. This variable repeat length is possible because the plate cylinder on a flexographic printing unit is removable and interchangeable with plate cylinders of different diameters. The flexographic package printer can minimize substrate waste by having an adequate inventory of plate cylinders of various diameters, and choosing the best cylinder size match that best fits the print dimensions. By contrast, most lithographic presses are limited to a fixed repeat length (often called a “fixed cutoff”). The plate cylinder used for most lithographic presses

cannot be changed to conform to various package sizes. In this case each package layout and design must fit into the "fixed" dimensions dictated by the press and plate size of the specific lithographic press.

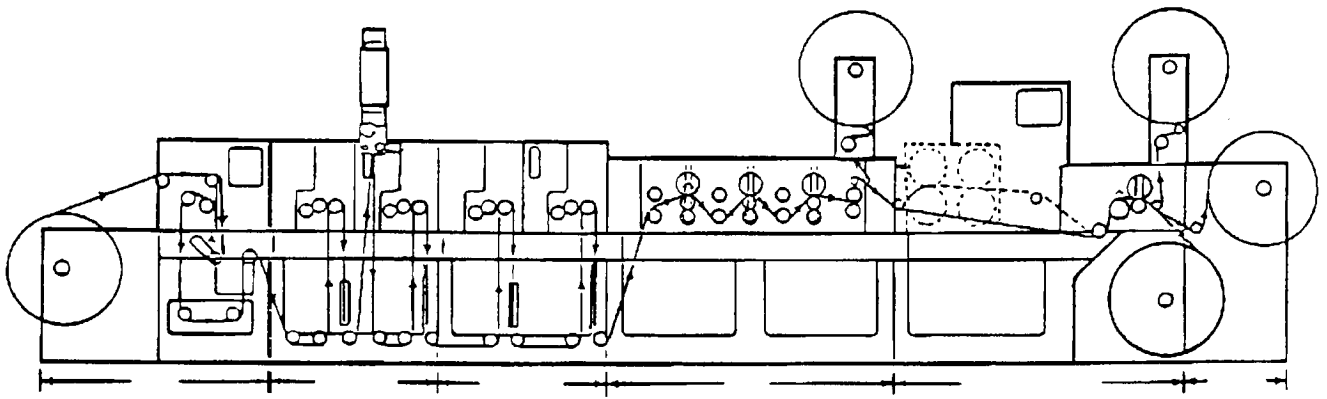
Flexographic plates can be mounted around the entire circumference of the plate cylinder, and images can be arranged to print a "continuous repeat", void of any seam area where the plates ends butt. Continuous repeats can also be accomplished by using laser engraved design rolls.

Press Configurations

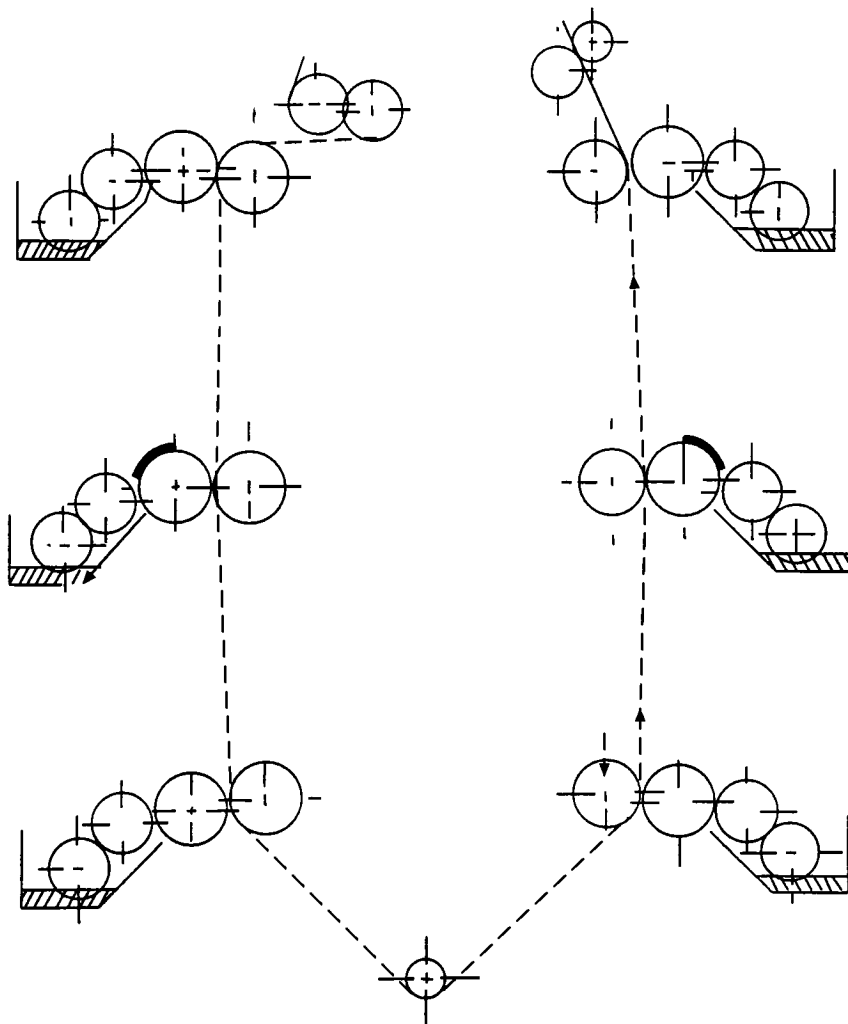
Flexographic presses can be built in any of three basic configurations; Stack Press, In-line, and Common Impression Cylinder (CIC).



(Fig. 9) Common Impression Cylinder
Flexography: Principles and Practices



(Fig. 10) In-Line Press
Flexography: Principles and Practices



(Fig. 11) Stack press schematic
Flexography: Principles and Practices

- Stack Press
- 1-8 color units
 - Web can be printed on both sides with some stack presses
 - Traps should be no less than $\frac{1}{32}$ " for thin films
 - Often in line with other converting operations, including polyethylene extrusion, lamination, rotary and flatbed die cutting, and sideseal bag converting.
- In-Line
- Up to 12 color units
 - Often used for printing thick substrates ie. corrugated, paperboard
 - Can print two sides (with the aid of a turn-bar)
 - Often in line with other converting operations
 - Not recommended for printing thin packaging film materials
- CIC
- 4-8 color units
 - limited to one sided printing
 - Ideal press for hairline register at high speeds on thin, stretchable films
 - Longer make-ready times required because of the inaccessibility of the printing units
- Corrugated
- Usually no more than 4 colors
 - All corrugated presses are sheet fed
 - Widths up to 120"
 - Less accurate register capabilities
 - Limited to one side printing

Multicolor Capabilities

Flexographic presses commonly come with multicolor capabilities. Recently the flexographic industry has experienced an increase in installations of 6 and 8 color presses. In some limited applications as many as twelve colors can be applied in one pass through a flexographic press. From a creative design perspective the possibilities for eye-catching color are greatly enhanced by a printing process offering so many color capabilities. Combinations of 4 color process and spot colors, multiple spot colors alone, or Hi - Fi process color printing, allow the designer a great deal of creative latitude when designing a graphic to be printed by flexo.

It is important to note that for transparent film substrates, the chances are good that one of the color stations will be required to apply a white back-up or "choke" plate. Without the white back-up, colors would appear flat and transparent. The white plate is a characteristic unique to processes utilizing clear or colored substrates.

Another important color characteristic of flexographic inks is that they are usually made from opaque or semi-opaque pigments. The color sequence usually adhered to for flexographic printing is lightest to darkest colors in the press units. Overprinting two or more spot colors will most likely result in the creation of an objectionable "mystery" third color in the overprint areas.

Reverse-side Printing

An exception to the rule of lightest to darkest color sequence occurs when a spot color or line art job calls for "reverse-side printing". Reverse side printing means the job is reversed laterally and printed on a clear substrate like polyethylene, polypropylene, or polystyrene. After printing, the graphics will be displayed from the "reverse" or substrate side, rather than the side of the substrate where ink has been applied. This technique is often used for non-food packaging, or for applications where another film will be laminated to the printed film.

Flexographic Plates

There are a many types of flexographic printing plates, with the primary differences being material from which the plate is made, and the plate thickness. The type of plate material to be used to print a flexo job is decided by the flexographer after consideration of the graphic elements they are asked to reproduce. Although few flexo printers print from both rubber and photopolymer plates, many have two or three types of rubber or photopolymer materials for platemaking.

Another important characteristic of all types of plates is durometer (a measure of the hardness or softness of a plate). "Printing plates (rubber or photopolymer compound), are soft and are of concern to the graphic designer."¹ Dot gain is affected by the durometer of the plate being used. Plates of higher durometer (harder), will print with less dot gain than softer plates. However, lower durometer plates transfer solid images more smoothly and completely than high durometer plates.

The plate thickness is dictated by the flexo printers' type of press and plate cylinder inventory. Generally speaking, wide-web printers print from thicker plates than do narrow web printers.

Molded Rubber Plates

The molded rubber plate has been used for flexographic printing since the 1930's. However, the introduction of the photopolymer plate in the 1970's marked the beginning of a period of steady decline in the use of the rubber plate.

From a design perspective, the important characteristics of molded rubber plates include:

- Molded rubber plates shrink shortly after they are removed from the molding press, consequently, plate films should be adjusted to compensate for shrinkage. The amount of shrinkage depends on the type of rubber being molded, but is typically

1.5%-2.0% along the grain of the rubber and .5%-1% across the grain of the rubber. To assure accuracy, the exact shrink factors should be communicated between production artists and plate makers.

- Resolving capability of a rubber plate is limited to 120 line screen.
- Molded rubber plates may be more difficult to register in the plate mounting step than photopolymer plates.
- Prints from molded rubber plates can only appear to be continuous repeat if images are nested in the job layout design, to "hide" the plate seam.
- It is difficult to mold accurate rubber plates larger than 24" X 36", consequently designs larger than 24" X 36" must be done by piecing together multiple plates for each color.

Laser Ablated Plates and Design Rolls

A design roll is a rubber covered roll that has been imaged by laser ablation. The design roll is seamless, and can truly carry images around the entire circumference. The laser ablation imaging process is direct to plate. This process can also improve register capabilities. "The specified trap between colors can be accurately attained, bleed can be provided, registration marks can be engraved as part of the design and eyespots or other devices can be precisely placed."² Laser ablated design rolls are often used for long run jobs that require continuous printing, and can be run in combination with other flexographic plates. Direct to plate laser ablation can also be used for imaging plates rather than entire roll. However a laser ablated plate must be mounted on a plate cylinder, and will not be seamless. Laser ablated plates are often used for short run and for spot coating on flexo or offset presses.

From a design perspective, the important characteristics of laser ablated plates and design rolls include:

- Resolution is limited to 100 line screen for tone reproduction, but can be 200 - 300 lines screen for tints.
- Laser ablated image carriers do not require film output.
- Laser ablated design rolls can be a truly continuous repeat design, laser ablated plates require nested images to give the appearance of continuous repeat.
- Plates or design rolls imaged on a circumference do not require distortion.
- Laser ablation can be performed on both rubber and sheet polymer materials.

Photopolymer Plates

Today, the photopolymer plate is the most frequently used plate for flexographic printing. There are two general categories of photopolymer plates available, sheet and liquid. The main difference between the two is the physical state of the raw material from the supplier. Sheet photopolymer is supplied in a solid state, while the liquid plate is supplied as a liquid which has about the same consistency as honey. The liquid solidifies when exposed to ultra violet light.

From a design perspective, the important characteristics of photopolymer plates include:

- Photopolymer plates have guaranteed resolving capabilities of 150 line screen. Some high-end flexo printers have actually printed from plates with 200 line screen.
- Prints from photopolymer plates can only appear to be continuous repeat if images are nested in the job layout and design to "hide" the plate seam.
- Most of the newest plate positioning and register devices rely on a "one piece" flexographic photopolymer plate.

- Some service bureaus and flexographic plate makers presently have the capability of filmless, direct digital imaging for conventional (non-laser ablated) sheet photopolymers.

Platemounting Systems

Offset lithography has long been able to take advantage of pin register for quick accurate color-to-color registration. "The first commercial machine for accurately mounting and proofing rubber printing plates was probably developed in the early 1940's by Franklin Moss, founder of the Mosstype Corporation."³ Until the recent adaptation of pin register and micro-dot register systems to flexographic plate mounting, color-to-color register was entirely dependent upon the skill level of the plate mounter. Many platemounters became highly skilled, while others were less accurate in plate positioning and registration, resulting in poor registration on press.

The concepts of pin register and micro-dot register was developed to make accurate plate mounting fast and easy for everyone, even the beginner. Pin register requires a systems approach. That is to say that each prepress station, right up to the critical plate making and mounting stage has to adopt pin register or micro-dot line-up techniques. Pin positions, or micro-dot targets must be accurately transferred through each step of pre-press through to platemaking.

Mounting Tapes

Mounting tape is the two-sided adhesive used for affixing flexo plates onto the plate cylinders. Mounting tapes also come in a variety of types and thicknesses. Two general types of mounting tapes are "hard" tapes, and compressible tapes. A compressible tape is actually a thin layer of foam coated on both sides with an adhesive. The thin foam layer acts as a shock absorber to minimize over-impression on the flexo plate. By contrast, hard tapes offer no shock absorbing characteristic and are only used to adhere the plate to the cylinder.

Research of various mounting tapes has shown surprising findings. For instance one test of five different mounting tapes found solid ink density variations from 1.34 to 1.66 by simply changing mounting tape. Dot gain is greater with harder tapes than with softer tapes, usually, the less dot gain the better. Soft cushion tapes however, do not provide for a uniform ink transfer in solid printing areas, often causing pinholes.

Cylinder preparation

Each cylinder should be checked for condition and accuracy before a plate is mounted on it. Cleaning, checking for defects, and checking for accuracy before mounting the plate will often save material waste, press time, and extra work.

- **Cleaning** — Plate cylinder surfaces should be thoroughly cleaned to provide the best possible surface for plate mounting. Improperly cleaned cylinders can cause inaccurate plate pressures by trapping ink or other foreign matter between cylinder surface and mounting tape. A cylinder surface with oil, grease or any other residue on it will not allow proper adhesion of the mounting tape and will eventually lead to plate lift. When cleaning a cylinder, it should be noted that many water-based inks require some type of detergent to rewet dried ink for cleaning purposes. Often these detergents leave an invisible residue or film on the surface of the cylinder that inhibits adhesion of tape to metal. Final cleaning of the cylinder surface should be done with a solvent that will leave no residue behind.
- **Gears** — Gears should be kept clean and well lubricated. Make a practice of noticing the condition of each with each job change. If they are removable, make sure they are tight when replaced.
- **Total Indicated Runout (TIR)** — Good pressroom practices includes the use of a dial indicator used to check cylinder circumferences and bearing accuracies. Runout of

each plate cylinder is important. Recommended tolerances for runout have been ± 0.001 " for line work and ± 0.0005 " for halftones, however, with today's more demanding quality requirements a good practice is to always work at halftone tolerances.

Endnotes for Chapter 3

1. Donald G. McCaughey Jr. *Graphic Design for Corrugated Packaging*
Jelmar Publishing Co., Inc.
P.O. Box 488
Plainview, NY 1995. p 21
2. Eugene L. Greene, Sr. *Flexography: Principles and Practices*
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Chapter 4

Substrate and Substrate Influence on Flexographic Printing

Substrate is a generic term for the packaging materials printed by flexography and other printing processes. "These materials aren't necessarily chosen for their printing characteristics, but because they're functional. Thanks to flexography's versatility, there is almost no material that has not or cannot be printed by it." It has been said that if any material can be put in a roll, it can be printed by flexography. The quality of a printed product is affected more by the substrate than the type of process that applies the graphics. Packaging industries utilize a wide variety of substrates to satisfy the demands of a wide assortment of packaged products.

Substrates can be classified into three general categories:

1. Paper/Paperboard

- kraft linerboard (corrugated)
- clay coated kraft (corrugated)
- solid bleached sulfate (SBS) (folding carton)
- recycled paperboard (folding carton)
- coated paper (labels, gift wrap)
- uncoated freesheet paper (paperback books)

2. Polymer Films

- (non-absorbent)
- polyethylene (PE) (dry cleaner bags, bakery, and textile bags)
- polypropylene (PP) (snack packages, candy wrappers, cookie packaging labels)
- polyvinyl chloride (vinyl films) (labels, wall coverings)

3. Multilayer/Laminations

- metallized papers (gift wraps)

metallized film (snack food bags)
polyethylene coated SBS (milk cartons)

The important characteristics of substrates as they relate to the printing process are:

Color — A printing ink is significantly influenced by the color of the substrate on which it is applied. The flexographic process is often used to print corrugated containers with unbleached brown kraft linerboard exteriors. Color matching on these types of surfaces is difficult to achieve.

Paper/paperboard — White, brown kraft, and a variety of colored papers.

Polymer films — Can be clear, white, combinations of white and clear, or colored.

Multilayered/Laminations — The color characteristics are decided by the top most layer with reflective qualities. Foils and metallized papers or films are silver, or tinted to a colored finish.

Whiteness/Brightness — The whiteness or brightness of a paper is the paper's light reflective qualities. Even on bleached or coated papers there are differences in the whiteness or brightness of a sheet. Paper containing a high percentage of recycled fiber may appear to be more off white than paper made from 100% virgin fiber.

Paper/paperboard — Whiteness and brightness increases with bleached and coated papers. Optical brighteners may also be added to paper to increase brightness.

Polymer films — White films can vary in opacity which will affect brightness. Clear films require a printed opaque white ink under color images. Colored films will not be included in this measurement.

Multilayer/Laminations — Decided by the top-most layer of film or paper with reflective qualities. Foil and metallized printing surfaces require a printed white ink under color images.

Opacity — All substrates have a measurable opacity rating. Opacity is the ability of a substrate to prevent light transmission. The more opaque a substrate, the less light will pass through. A color printed on paper or film with a low opacity rating will be influenced by what lies beneath the substrate.

Paper/paperboard — Thin lightweight papers have lower opacity and will be more prone to ink show through.

Polymer films — On clear substrates, opacity depends on the opacity of the printed white ink layer. The opacity of white or colored films is dependent upon the film manufacturing process, films may be made white or colored by adding the appropriate colored resin to clear resin during the extrusion process. Darker films may tend to be more opaque than lighter films, but all films can be manufactured with high opacity.

Multilayered/Laminations — Usually high opacity is achieved by the multiple layers of opaque or semi opaque substrates.

Smoothness — Smoother substrates allow for the printing of higher line screens, Rough, irregular surfaces such as newsprint and corrugated liner board require coarse screen rulings. "Defects in smoothness can be described in two ways, macro and micro. Macro refers to irregularities that can be seen with the naked eye ... Micro refers to a small area with defects not readily seen with the naked eye ..."²

Because the flexographic ink is fluid and generally not regarded as tacky, fiber pick (a

problem common to lithographic printing) is not an issue.

Paper/paperboard — Newsprint, corrugated linerboard, and paperboard are relatively rough. Calendered and coated papers are the smoothest.

Polymer films — Polymer films are the smoothest printing surfaces, consequently roughness is not a problem, however, ink adhesion and whet-out sometimes is a problem.

Multilayered/Laminations — The smoothness is dependent on the substrate used as a printing surface.

Absorption— On substrates with little or no absorption characteristics the ink will dry at the surface providing more saturated color and less dot gain for halftone printing. Papers with low absorption rates are referred to as having high “hold-out”. This means the paper holds or prevents the ink from absorbing into the sheet.

Paper/paperboard — Corrugated, newsprint, and paperboard are very absorbent. Calendered and coated papers are less absorbent and exhibit high ink hold out.

Polymer films — Polymer films are non absorbent and exhibit the highest ink hold out.

Multilayered/laminations — Absorption characteristics are dependent on substrate used as a printing surface.

Gloss — Coated papers and films have gloss characteristics that influence the gloss of the inks that are applied to them. High gloss finishes are very reflective, and tend to be reflective. Matte or low gloss finishes can be applied to all substrates by matte coatings, and uncoated and uncalendered papers have low gloss.

Paper/paperboard — Calendered and coated papers are high gloss while corrugated linerboard, uncalendered newsprint, and paperboard have low gloss qualities. Gloss can be increased after printing by applying an overprint varnish or lamination.

Polymer films — Films are higher gloss than the highest gloss papers. Films can also be produced with a matte finish.

Multilayered/laminations — The gloss of the printing surface is dependent on the substrate used as a printing surface, gloss can be increased after printing by applying an overprint varnish or lamination.

Caliper — Caliper is the thickness of a substrate. Caliper is usually measured with a micrometer. Thin sheets of paper may have a caliper as small as 0.002", and thicker sheets may have a caliper of 0.010". Paper with caliper readings greater than 0.010" are often referred to as paperboard. The caliper of paperboard may be as much as 0.030". Polymer films are by definition thin. Dry cleaner bags are 0.00065". The thickest caliper used for flexible packaging are 0.005" to 0.006".

Thin films require printing conditions with very accurate tension controls. Paperboard caliper should be uniform and free from low spots that will lead to print skips (voids) on the flexo press. For all substrates caliper uniformity is critical.

Paper/paperboard — Thinner papers are more consistent in caliper paperboard may have inconsistencies in caliper.

Polymer films — Thin films are susceptible to stretch during printing. Caliper inconsistency will cause misregistration, and print wrinkle problems.

Multilayered/laminations — Caliper increases as layers are added. Extremely thin layers

may be laminated together to attain required barrier and printing surface properties.

Endnotes for Chapter 4

1. Edward Mayeda. *Flexography: Principles and Practices*
Foundation of Flexographic Technical Association,
Ronkonkoma. 1991. p 289
2. Ibid p. 294

Chapter 5

Flexographic Design Considerations

Trapping

Trapping is the overlap of color to avoid misregistration during printing.

Misregistration is caused by substrate handling and tension problems on the press, irregular or inconsistent plate elongation from one color to the next, inaccuracies in the plate mounting, and limited register capabilities. A preliminary test run and analysis of the press will determine the registration tolerances. Typically, a designer will build traps into the file if the job is a simple one, otherwise trapping will be handled by using an option in a drawing or trapping software program like Trapwise or DKA Island Trapper, or handled entirely by the prepress service bureau. The best trapping applications allow for partial traps—where only areas of an image that require trapping can be affected, while leaving all other areas at their original dimensions.

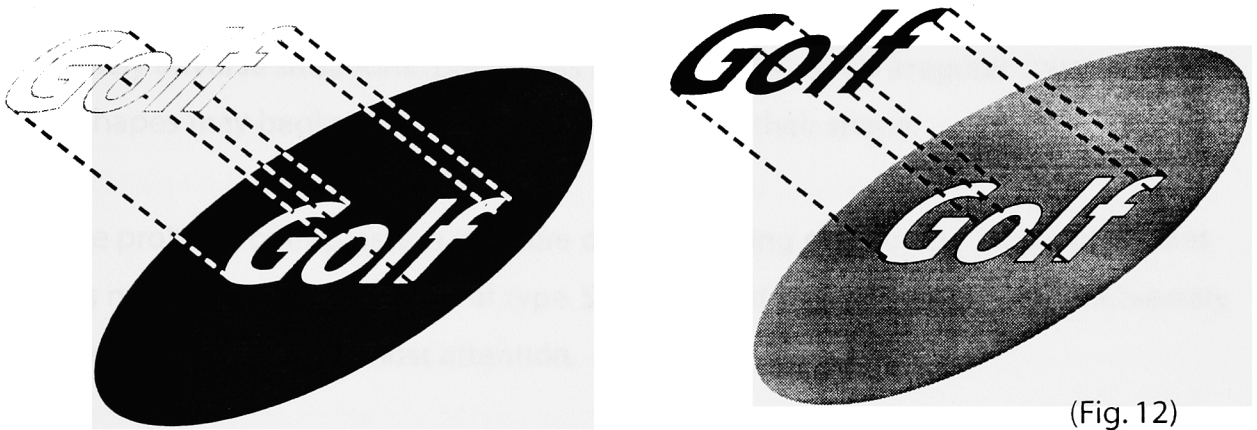
" Traps serve the same purpose in packaging as in commercial printing. There are two primary differences: 1) in packaging there are generally more colors, and 2) with flexographic printing larger traps are required to compensate for misregister."¹

Guidelines when designing for flexography would include avoiding tight registration requirements, creating sufficient trap for anticipated misregistration, designing with the dominant color printing over the lighter color, and avoiding trapping of gradations (fig 12). Trapping may cause a dark line where the colors overlap.

A label printed on a narrow web press should be trapped at a minimum of 0.005"—some require as much as 1/32", or 0.031" compared to average traps of 0.002" - 0.005" for lithography. A typical trap area for a job on wide web polyethylene might be 1 point (1/72", or 0.014"). However, if an objectionable dark trap line is created by the 1 point overlap, the designer may plan for a trap of .5 points. Trapping for linerboard or corrugated may require 1/64" to 1/8".

Trapping

Designers need to understand the trapping problems unique to flexography. The designer, service bureau, and the printer should communicate and agree on the requirements of the job, and who will be responsible for the trapping.



Trapping is accomplished by slightly expanding lighter colors to overlap darker colors, even when slight register variations occur.

Typography

The soft flexographic printing plate, irregular substrate surfaces, and the fluid flexo ink can have a profound negative impact on text sized type printed by flexography. The line strokes of smaller point sizes of type often increases during the printing process because of the compressibility of the printing plate and the fluid nature of the flexo printing ink. Negative or reverse type often tends to become pinched or “fills-in”. In extremely adverse situations (poor press equipment or rough irregular substrates), lettershapes may begin to appear rounded and lose their shape.

It is the problem of impression pressure on the printing plate in the printing nip that causes most of the deformation of type. Smaller point sizes of type are most adversely affected and require the most attention.

For wide-web polyethylene printing typical minimum type sizes are: Positive type — 6 point for san-serif fonts and 8 point for fonts with serifs. Reverse type — 9 point minimum (it may be a good idea to spread 9 point reverse minimum type). For narrow web printing some fonts may be printed as positives as small as 3 point type, while others may lose shape at 6 or 8 points.

When designing a job to be printed on corrugated, it is best to choose a medium weight typeface, and to avoid serifs for any type that is smaller than 18 point. A good rule of thumb is to avoid type that is made up of strokes width less than 1/32” line widths for positive type., and 3/64” for reverse type. All type should be set at normal letterspacing.

To help compensate for the “weight gain” of flexographic type, it may be possible to use the trapping technique of spreads and chokes. Chokes are used on positive type, spreads are used on negative type. Some programs such as Freehand and Illustrator, allow the designer to adjust the thickness of the type. This type effect can be

achieved by selecting the text, converting to a "path" and then specifying a value for the "width" for the outer and/or inner "stroke" of the type. In some cases, these programs allow the designer to simply select the type and choose a desired effect such as "heavy" to thicken the selected type to print bolder.

In prepress design, some compensation can be done by choosing either a lighter face or a bolder face. For example, if bold positive type is desired, use a medium weight face. If a medium negative type is desired, specify bold face on the desktop. However, should this technique of selecting style attributes be selected make sure the printer font selected is installed on the out-put device to be used in the production process.

Letter spacing must be considered when designing for flexo. In offset, letters can be squeezed together to form a denser appearance on the page. The same spacing printed in flexo may cause the letterforms to merge together to become unacceptable. However, when printing fine-serif type with major letterspacing, the serifs may begin to lose their shape. Ideal letterspacing occurs when letters are close enough together to lend support to each other while under the pressure of the printing nip, yet not so close that they begin to join together under that same pressure.

Whenever possible, san-serif fonts are preferred for flexo printing, however, the larger the point size being printed the better the chances that the font will reproduce as desired.

Unofficial Industry standards and recommendations for type:

- 6 point minimum for positive type, 9 point minimum for reverse or knock out—wide web
- 4 point for positive, 6 for reverse on narrow web

- When using small size type avoid fonts with fine serifs or delicate strokes
- Kerning may cause squeezing across cylinder. Avoid tight line spacing
- Letterspacing and/or line spacing may increase slightly in the curve dimension due to plate elongation during the platemounting phase.
- All positive text should be printed in a single color if possible.
- Avoid placing fine type on the same color plate with line work and solid printing areas.
- Specify type thoroughly and accurately to the service bureau or flexographic pre-press department.
- Avoid reversing type out of two or more colors unless a dominant color outline is used.

Plate Distortion and Elongation

From a prepress and design perspective, one of the most important characteristics to understand about flexography is the phenomenon of plate elongation. As a flexographic plate is mounted on a plate cylinder, a natural elongation occurs in the curve around the cylinder direction. Consequently, if the printed design is meant to be a circle, the image must be compensated by distorting (shrinking) the image in the around-the-cylinder or curve dimension, and the image on the resulting plate films may appear to be oval. After proper distortion factors have been applied and the plate has been mounted and printed, the oval will elongate to form a circle. The same distortion requirements hold true for all images.

This is a general formula used for calculating plate elongation:

$$\frac{\text{factor based on plate thickness}}{\text{cylinder repeat length}} = \text{stretch per inch}$$

Sample calculation used for rubber plate distortion;

T = Plate thickness with mounting tape; π carried to 4 decimal places = 3.1416;

R.L. = Repeat Length of the plate cylinder

Plate Thickness = 0.107" Repeat length = 18.8"

Mounting Tape Thickness = 0.020"

TOTAL 0.127"

$$\frac{\pi \times 2 T}{R.L.} = \frac{3.1416 \times 2(0.127)}{18.8} = 0.0424"$$

This means that for every linear inch of plate used in the around the cylinder or curve direction, the images will increase at the rate of 0.042"/inch.

To apply the calculation to a design measuring 12 inches in the curve dimension;

$$12" \times 0.042" = 0.509"$$

This means that plate films should output to measure 11.490" in the curve dimension, or, 95.7% in the curve dimension, and 100% in the other dimension (ignoring any plate shrink as discussed in Flexographic Plates section). Software written specifically for flexography can compute plate distortion factors, and apply them to each color separation.

This formula shows that as the plate thickness increases the stretch factor increases, and as the cylinder repeat length decreases, the stretch per inch increases. The flexographic industry is currently using a variety of plate thickness in combination with a variety of mounting tape thicknesses. The type and thickness of the plate being used is dictated by the type of press being used and the type of work being printed on the press. Some typical plate thicknesses for some of the larger flexographic printing markets are;

Combined board corrugated	0.250", or 0.107"
Wide web flexible packaging, preprint, and folding carton	0.107", or 0.067"
Narrow web label	0.067", or 0.045"
Newspapers	0.024"

These are only examples of plate thicknesses currently being used. Recently there has been a trend toward thinner plate technology for flexographic printing.

There exists today many software packages with the capability of shrinking or distorting an image in one dimension. To be sure that the design will be the correct size and shape, the design has to be out put to film after plate thickness has been determined and the proper distortion factor applied.

The plate distortion step should be performed as close to the film out-put or plate setting stage as possible, and can be performed by the raster image processor (RIP) operator using distortion software.. The actual distortion process need not be of concern to the designer.

Halftones and Screening

The flexographic printing process historically has been recognized for it's ability to apply spot color and line art graphics to a wide variety of substrates. However, it is the

recently improved capability of high quality, economical four-color process printing that has given the flexographic process an edge over other processes for packaging graphic applications.

Dot Gain

All printing processes are subject to the natural and unavoidable occurrence called "dot gain". Dot gain can be described as an increase in the diameter of halftone dots from the film to plate and a further increase in size from plate to print. For example, when the image setter outputs a 50% screen film dot, the flexographic platemaking exposure step may cause that 50% film dot to "grow" to become a 51% dot area on the plate. This is a small and relatively insignificant gain in comparison to plate to print gain, where a 50% film dot may eventually print on a flexographic press as a 65% or greater print dot.

Halftone dots can be generated in a number of shapes including the square dot, the elliptical dot, octagonal dots, and symmetrical and asymmetrical round dots. Square dots begin to join at 50% (arranged in a checkerboard pattern), and the connected areas continue to increase as the dot area increases. Dot gain occurs at the perimeter of the halftone dot, as individual dots join the perimeter area increases causing a large density jump at the dot area where the contact first occurs.

To minimize the large density jump, a round dot screen is the ideal for the flexographic process. The dots of a round dot screen do not touch until the dot area is in the 65% range for the symmetrical round dot and the 75% range for the asymmetrical. The best round dot screening software produce the asymmetrical dots that do not begin to touch until the 75% dot area. Dot gain is less at these higher dot areas, and is more easily controlled or compensated for.

The fluid ink and compressible plate used for flexographic printing tend to increase dot gain, making dot gain compensation an especially important step for high quality tone reproduction. Each different substrate printed by flexography will also influence dot gain characteristics. It is important to understand is the fact that dot gain compensation is different for each printing process, for many different substrate surfaces, and often for different printing presses within the same process. Fortunately, dot gain can be predicted and compensated for by a color separator, or adjusted for compensation in Photoshop, or in RIP based calibration packages like AGFA Calibrator.

One of the most important considerations for a successful four-color tone reproduction is an understanding of the ink hue and dot gain differences that exist for the flexographic printer. When high quality tone reproduction is important, the best results are obtained by first performing a preliminary press test run called a fingerprint. A "fingerprint" of the press will provide important information to the color separator or the desktop designer. By printing a target of this type under controlled conditions, color separation films can be adjusted to compensate for flexographic dot gain and ink hue.

Highlights

Another important consideration when color separating for the flexographic process is the placement of the minimum highlight dot. Most photopolymer flexographic plates are capable of holding a two percent highlight dot. Since the highlight areas of a flexographic print show the most dot-gain, it is extremely important that the minimum highlight dot capabilities be discussed with the printer before separations are made.

Vignettes

Flexographic highlight dot-gain makes it difficult (if not impossible) to print a fade away to white paper without a harsh break at the highlight edge. When designing for flexo, it

is best to fade off the end of the design, or border the highlight end of the vignette.

Dot Shapes

Without question, a round dot screen is the ideal for the flexographic process. There are however different versions of round dot screening software. Individual film dots on the best round dot screens for flexography do not begin to touch until they reach the 70-75% region. Most design software can provide for a round dot, however dot shape should be determined as close to the platemaking step as possible, either at the film imagesetter, or the platesetter. Consequently, the same type of dot should be available on the RIP and imagesetter, or platesetter.

Screen Ruling and Substrate

The selection of the proper screen ruling is critical to four color process flexography. Screen ruling capabilities are most often dictated by the type of substrate being printed. The corrugated industry, for example, prints halftones screened at 45, 55, 65, or 85 lines per inch. Flexographic newspaper printers print halftones screened between 65 and 100 lines per inch. Flexible packaging on films substrates is commonly done at 120 to 150 lines per inch, and high quality label printers have the capability of printing 200 line screen images.

Anilox cell count and separation screen ruling should be correlated to achieve the best flexographic print. A general rule of thumb is that the separation screen ruling should be no more than 25% of the anilox that will be used to apply ink to the plate. The ideal from an ink application to the plate perspective, is to have a minimum of 4 anilox cells on top of each halftone dot.

Screen Angles

Cells are engraved on an anilox roll at one of three possible angles; 30°, 45°, or 60°. To avoid anilox moire', films or plates screen angles should be at least 7.5° away from the anilox cell angle. Cyan, Magenta, Yellow, and Black screen angles should also be set at

angles at least 15° apart from each other.

Stochastic Screening

Stochastic or Frequency Modulated (FM) screening for flexography may offer some advantages over conventional half-tone screening. FM screening eliminates the possibility of moire', and also allows the flexographer to print high fidelity color. High fidelity color is a technique used to extend the printed color gamut by printing a total of six or sometimes seven process colors. The multi-color capabilities of flexo and the random dot pattern of a stochastic screen to avoid moire' make high fidelity color an excellent design option.

The dot size used for FM screening is extremely small and comparable in size to the highlight dot of conventional screening. The flexo highlight dot is subject to excessive dot gain. Consequently, FM screening for flexography should not be attempted unless the printer and color separator have performed press fingerprints to determine the ideal dot size to be used, and accurate dot gain compensation curves.

A final point about films made for flexographic plate making: The polymer plate material is very soft and will easily trap air between the film and the plate during the plate exposure. Consequently, when making films for sheet photopolymer plates, a special "matte emulsion" film must be used to avoid out of contact areas during plate exposure.

Step & Repeat

The concept of printing the same image multiple times across the width of a web and around the entire repeat length of a cylinder is known as step and repeat. Package printing industries apply this concept in combination with variable repeat length and variable web width capabilities. The ideal is to maximize substrate usage and productivity by fitting as many repeated images on the flexographic plate as possible. Often, a technique called nesting will be required. By placing duplicate package lay-

outs or label graphics strategically between other lay-outs or graphics, the job can be designed for maximum productivity and minimum material waste. The best method of nesting images is to cut and paste original graphics. This step in the flexographic prepress process is done in the production art stage. Most standard layout programs do not have the capability of step and repeat. Step and repeat can be performed on some illustration programs and by specialized software that will create templates to allow the production artist the ability to impose multiple images for film output, while working within the confines of web width limitations and plate cylinder repeat length.

In the past, multiple sets of flexographic plates were made from one set of films, and imposition was performed in the plate mounting stage. Today, photopolymer plates and pin register or micro-dot plate register systems require one-piece plates, and one-piece plates should be made from one piece films. The need for large one-piece films for wide web flexographic printing applications has brought about the need for large format imagesetters, and film processors.

The flexographic printing process is sometimes prone to a problem known as "plate bounce." This problem is especially prevalent when lead edges of the printing plate run parallel to the printing nip, and can be avoided by a lay-out technique called staggering the plate. Not all designs will allow this technique, but when possible, staggering the plates may provide for higher press speeds. Another technique used for minimizing plate bounce is the use of "bearer bars" in the non-image areas. Bearer bars provide continuous contact between the plate surface, the anilox, and the impression roll.

Die-Cutting & Converting

When designing graphics for a die-cut label or die-cut folding carton, an artist must take care to place all graphical elements in the correct positions. A die-cut folding carton is an excellent example to illustrate the fact that the first requirement for design is that it conform to the shape of the package.

Packaging engineers often use computer aided design (CAD) systems to design folding cartons, corrugated containers, or rigid paper boxes. CAD files can be exported to Illustration programs to provide the designer a two dimensional layout of the job.

The designer should remember that the eventually the design will be converted to a package, and each package forming process has special considerations that may be adversely affected by the design of the package. Some important considerations when designing for a job to be a die-cut box or converted to a bag include:

- **Bar Coding** — Bar coding can be created on the desktop or provided through another outside source. In either case, bar codes should run parallel with the web direction, and should be cut-back to compensate for flexo gain characteristics.
- **Bleeds** — For die-cut jobs it is important to have a copy of the die being used. This will allow the designer the opportunity to see where packages fold and join, and where bleeds will be required. The amount of bleed required is dependent on the press being used. Bleeds can be created with standard illustration programs.
- **Cut Areas** — Because flexographic printers do in-line flatbed or rotary die-cutting, the die must be held in register with the colors being printed on the package. Important graphic elements should not be placed too close to cut areas.

- **Glue Areas/Seal Areas** — To assure sealing when forming a folding carton, glue areas should be free of ink and varnish. Polyethylene bags are often heat sealed. All areas in or near a heat seal should be free of ink. Heat sealing is also done on some folding cartons, for example milk cartons, have been laminated with polyethylene and will be heat sealed at the seams. The design should be void of ink in the heat sealing areas.
- **Score lines** — Die-cut folding cartons usually fold at score lines. The designer should consider a score line a critical registration area.
- **Varnish Areas** — Many folding cartons or labels require the application of an over-print varnish. In some cases, variable information like freshness dating or product coding will be added during packaging. Often these areas must be free of varnish. This application requires a special "spot varnish" plate.
- **Windows** — Die-cut windows should be clearly indicated. A window used for folding carton or label work presents problems in the die-cutting operation. Before designing a window, check with the printer or package convertor to make sure that windowing is within their capabilities.

Prepress Output

After a design has undergone the required production art trapping, distortion, and imposition steps, it is ready for film output or, in some cases it is ready to go directly to digital platemaking.

Today's film output devices include three basic components:

Raster Image Processor (RIP) — The RIP converts Post Script data to an image composed of pixels. Basically, the RIP drives the Image Setter, using the Post Script file as a map. Most RIPs in use today are software installations on PC, Mac, or UNIX

systems. The RIP drives the Image Setter, and the speed of the Image Setter dictates the rate of film output. Complex files can take a long time to RIP, and may create problems with the Image Setter.

Imagesetter — The Imagesetter is the film imaging device. Imagesetters utilize a laser light source to transfer digital images to film.

Imagesetters used for the flexographic process have some unique requirements.

- Accuracy — The nature of the flexographic process includes a number of areas that might lead to print misregister. When precise register is required, the imagesetter being used should be the more accurate “Drum Imagesetter”, rather than its predecessor, the flatbed capstan imagesetter. However, capstan devices are suitable for single color jobs with less demanding register requirements, and are especially useful for unusually long jobs. Capstan devices can output film up to 80”, while drum scanner lengths are limited to the circumference of the imaging drum.
- Size — The imagesetter should be large enough to handle the largest films required for platemaking.
- Film — The imagesetter must be capable of handling 0.007” matte emulsion film.
- Calibration — It is imperative that the imagesetter be properly calibrated. Film dot percentages below 10% should not vary by more than 1% from the required dot area. Film dot area over 10% should not vary by more than 3% from the required dot area.
- Uniformity — Light screen tints should be a uniform dot percentage, with no variation in size between individual dots.

- Shape — The imagesetter and RIP screening information should be capable of outputting a “hard” round dot.
- Resolution— Resolution should be adequate for the screen ruling to be output, (1200-3600 dpi).

Processor — Because flexographic plates require a relatively lengthy exposure, the film density becomes an important factor. Imagesetter exposure levels and film processing chemistry should be adjusted to provide D-Max areas of 4.0, and D-Min of 0.04 or less.

Proofing

“Proofing” for a flexographic job is not always a clearly defined activity. Historically, a flexographic proof had been a plate proof made on a mounter-proofer during the plate mounting procedure. This practice continues today in many wide web flexo applications. The mounter-proofer proof is not appropriate for color matching. Instead, this proof is used internally to verify plate register, plate quality, and plate content. This type of proof is not used for customer approval.

A “Contract Proof” is a facsimile of the job a printer agrees to reproduce, the customer and printer sign a contract for printed material based on a contract proof. The typical “contract” proofing system used for offset lithography is not suited for flexographic package proofing. Basically there are three general problems associated with offset proofing when applied to flexography.

1. Substrate — Most proofing systems proof to a limited number of substrates. Flexographic package printing is done on a wide variety of substrates, and colors proofed on any substrate other than the one to be printed will show color variation when compared to the live press run.

2. Spot Color Matching — Film based or digital proofing systems are based on CMYK toner applications. Many of the packaging graphics are line art and spot color, not screen tints of CMYK..
3. Half-tone Dot Gain Compensation — When a proof of a process color graphic is required, most film based proofing systems are not calibrated for flexography. Proofing systems like Imation Matchprint and DuPont Chromalin were designed for offset lithography. These systems were design to replicate dot gain as it would typically occur in offset lithography. To use these proofing systems, the flexographer has to out-put two sets of films: one set compensated for flexographic dot gain (cut-back dot percentages), and sent to platemaking, and one set with increased dot percentages to replicate on press dot gain, used for proofing.

Most flexographic printers use cut-outs and mock-up “dummy” packages for proofing purposes. Digital proofs can be made from an ink jet or dye sublimation printer and used as a facsimile for the mock-up.

When critical spot color matching is required, the flexographic printer will often provide the client with a catalog of colors applied to the substrate to be used. These colors may be variations of conventional color matching systems like Pantone, or Focaltone, they may be colors formulated by the printer, or they may be colors requested by the buyer. In any case, spot color matching should be visually evaluated and numerically verified by color measurement instruments.

Half-tone film based systems can be used for process color flexographic proofs, however the current systems will continue to require two sets of films be produced one for plates, and one for proofing. Digital proofing systems (both halftone and continuous tone), when used within a color management environment, can be manipulated to output contract proofs for flexographic printing. When used in a color management environment, digital proofing can eliminate the need for an extra set of films for proofing purposes.

Endnotes for Chapter 5

1. Mark Samworth. *Desktop Prepress for Flexography*
Du Pont Printing and Publishing
February 1992

Chapter 6

Summary and Conclusions

The flexographic printing process has evolved from letterpress to become the most adaptable process currently used for packaging graphics applications. Because the process is unique, there are many unusual design features that should be considered during the pre-press stages of a flexographic printing job.

Add to the unique flexographic design features the design features that are unique to packaging requirements and those that are unique to various substrates and design can quickly become a nightmare. In order to create successful designs for a flexographically printed job it is useful for the design and pre-press personnel to have a basic understanding of the process, and its unique design considerations.

The design and pre-press personnel may also find it useful to understand those features of a flexographic printing system that offer a wider latitude of design considerations, like that of multi-color capability.

The most important areas of flexographic design are as follows:

Trapping; Generally speaking traps need to be larger for flexographic printing than traps for other printing processes. The type of press being used for printing and the substrate being printed also should be considered when deciding what trap measurements are appropriate. The best register (and so the least amount of trap requirements) can be achieved on a common impression cylinder flexographic press. Traps for prints to be done on an in-line or stack press should be larger than those intended for a CIC press. Thin films of polyethylene are the most difficult substrates to print without stretch, consequently these films may require larger areas of trap than designs to be printed on more stable films such as polypropylene.

Typography; The flexographic plate may cause type to distort somewhat during the printing process. A natural and unavoidable stretch occurs in the web or machine

direction when the flexographic plate is mounted, this plate stretch may cause an increase in line spacing to blocks of text composed in that direction, or an increase in letterspacing when text is composed to run parallel with the web direction.

Abnormally high pressure in the printing nip can cause a significant increase in the weight of type selected by the designer. Reverse type may be "pinched" by the excess pressure. Wider webs and rougher substrates like paperboard are especially prone to excess pressure being applied in the printing nip.

Plate Elongation; Unlike any other printing plate, the flexographic plate will elongate or "stretch" during the plate mounting process. The elongation for each design must be compensated for in the pre-press stage. General axioms to apply are: 1. The thicker the plate, the more the stretch. 2. The smaller the cylinder to be used for platemounting, the more the stretch.

Halftones; The flexographic plate has its own dot gain characteristics, add to that fact the fact that each substrate will also contribute to differences in dot gain and tone reproduction. Highlights are also a challenging area of print for the flexographic process. Special care should be taken when generating film separations for flexographic printing. The best results for halftone printing can be achieved by first performing a "fingerprint" test run on the flexographic press in question. This test will provide the color separator with the information necessary to apply the correct gamma for the printing conditions. The rougher the substrate, the greater the dot-gain. The durometer of the plate being used and the type of mounting tape also have a significant influence on dot gain.

Screen Angles; The cells of the flexographic anilox roll are engraved in either a 30°, 45°, or 60° angle, these cell angles make a one color moiré possible. Common practice when screening for a flexo job is to re-angle screens by either adding or subtracting 7.5° from standard offset screen angles.

Many of the unique packaging considerations are important to design and pre-press for flexographic printing. The following techniques are often used for packaging design and pre-press.

Step and Repeat; Many smaller packages or labels are often printed multiple times on wider webs. When step and repeats are necessary, images may be turned 90° or 180° to allow for the best fit and least amount of waste.

Stochastic Screening; Stochastic screening may be used when printing hi-fidelity color or when printing multiple screen tints. Halftones for corrugated are best suited to stochastic screening techniques.

Diecutting and Converting; Package printing usually is only one step in a package conversion process. When designing graphics for packaging special requirements must be adhered to. For polyethylene and other substrates that will be heat sealed it is important to keep heat seal areas free of ink. A folding carton to be die-cut should have all image elements located such that when the box is formed they will appear on the correct panel. It is also important to keep glue areas free from coating or ink that may interfere with bonding.

Appendix

Annotated Bibliography

***Flexography: Principles and Practices*¹**

Flexography: Principles and Practices is a comprehensive technical textbook covering the flexographic process. The book includes detailed information about flexographic prepress design and printing. The book covers extensive details related to the psychology, aesthetics, functionality and purpose of designing packaging printing.

Flexography: Principles and Practices also details the mechanics of design preparation. Although there are no established standards for flexographic design, the book does include general discussion about designing for the flexographic process. "Once all the input has been evaluated, and before the first line is drawn, the designer must remember that the extent of the design's creative limits are governed by production and equipment capabilities."¹

The book goes on to describe general information related to substrates and materials, typography, screen ruling and registration.

Flexography: Principles and Practices also contains information related to the flexographic printing plate and plate elongation. The book describes plate making processes, laser engraved rolls and plates, photopolymer plates and rubber plates. The book also describes the flexographic ink system and the various press configurations used by flexographic printers.

Graphic Design for Corrugated Packaging²

Graphic Design for Corrugated Packaging is a book written specifically for the corrugated printing industry. This is an excellent reference for anyone interested in designing for printing on a corrugated medium. The author has over 30 years of experience in graphic design and corrugated platemaking.

The book is a comprehensive look at the corrugated printing industry and the design features that are unique to printing on a corrugated substrate. The author describes the characteristics of a corrugated board printing surface, including descriptions of problems commonly caused by corrugated manufacturing processes.

The book discusses prepress for corrugated and points out one of the problems introduced by the proliferation of the desktop design: "The impact of digital technology has changed forever the manner in which most graphic designers approach a design on a corrugated box or display. Electronic prepress, with its never-ending selection of graphic software for image and text manipulation and with communication links between CAD/CAM design and production systems, have merged the creative and production phases of the design to give the designer the flexibility and control never before realized with traditional methods of art production."

The book also describes general principles of graphic design as they relate to advertising and identification concepts. Also, although there are no officially published standards for corrugated graphic design, a chapter entitled "Suggested Corrugated Graphic Standards" identifies many of the specific design features related to point size of type, screen ruling, illustrations and computer design that have commonly been successful in the corrugated industry.

Desktop Prepress for Flexography³

Desktop Prepress for Flexography is a brief general article that describes many of the differences in design features between publication and commercial markets and packaging markets. The article is an excellent source for those who are interested in the design feature differences that exist between the aforementioned market segments. The author notes "Unlike publication and commercial markets which utilize tools designed specifically for their application, packaging pioneers are forced to use products made for publication and commercial markets to do packaging work."

Packaging Guidelines tips and techniques for assembling electronic packaging file⁴

Packaging Guidelines tips and techniques for assembling electronic packaging files is a manual which describes prepress packaging desktop design techniques for folding cartons. It is strictly an instructional manual and offers only instruction on the production side of designing folding cartons.

Survival Shift⁵

Survival Shift, an article from Package Printing magazine details the typical prepress workflow for a leading label printer. The creative companies were already doing artwork on disks. In some cases they also hoped to provide stripping capabilities as a value-added service. Unfortunately, most of these companies didn't understand the printing process they were working with, particularly as they apply to packaging. They might have been up on desktop layouts for commercial offset work, but they certainly didn't understand the peculiarities of the flexographic process." The remainder of the article discusses solutions to these issues, and also points out many of the common errors made by novice flexographic designers.

Making It Big With PostScript Prepress

Making It Big With PostScript Prepress is an article which describes prepress equipment and techniques. The article describes the benefit of using open prepress systems and PostScript-capable laser imagesetters.

This article also discusses many of the unique design features to consider when designing for flexo. "Screen angles are particularly important, because you can get one-color moiré in flexo without them."

Endnotes for Appendix

1. Veronica Michalowski. *Flexography: Principles and Practices*
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2. Donald G. McCaughey Jr. *Graphic Design for Corrugated Packaging*
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4. Anon, *Packaging Guidelines, tips and techniques for assembling electronic packaging files*.
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6. John Hebert, Hebert Communication. *Making It Big With PostScript Prepress*
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February 1994

Glossary

Absorption. Penetration of one substance into another.

Adhere. Two surfaces sticking together, ink adhering(sticking) to paper.

Adhesion. Measure of adhesive properties between two materials.

Aniline Printing. The original name given to flexographic printing.

Anilox Roll. Engraved metal roll used to meter ink in the flexographic inking system.

Applicator Roll. Tint or coating roller.

Artwork. Creative output of the lay-out and design artist. Artwork can be used to reference original design art and also mechanical or camera ready copy.

Bare Cylinder Diameter. The actual diameter of plate cylinder, without plates or mounting medium considered in the measurement.

Bleed. Printing defect. Usually caused by incomplete drying of an ink causing it to migrate into all inks printed on top it.

Design technique. Printing beyond trim or score dimensions.

Blocking. Unwanted adhesion within layers of a wound roll. A roll that has stuck together or blocked is virtually impossible to unwind.

Bold Face. **This is bold face type**, this is regular type.

Bounce. A flexographic printing problem wherein the plate cylinder physically moves away from the anilox or impression cylinder because of a jarring contact between the printing plate and the anilox or impression cylinder.

Brightness. A measure of the whiteness of printed or unprinted papers.

Calender. A method of altering the characteristics of paper by passing it through a group of rollers, similar to nip rollers. Calendering a paper reduces caliper, increases density, and improves smoothness and gloss.

Caliper. Thickness, usually measured in thousandths of an inch.

Centipoise. Absolute viscosity. A measure of viscosity as compared to the viscosity of distilled water. Water's viscosity in centipoises is 1, motor oil's viscosity in centipoises is 100.

Central Impression Press. (CIC) A printing press configuration that positions all color decks around a common impression cylinder. The CIC press configuration offers web support throughout the printing operations, and optimum registration capabilities.

Chill Roll. A water cooled roller designed to cool a web and in some instances set ink. Chill rolls are positioned after press drying operations.

Circumference. The distance around a circle.

Circumferential Register. A reference to the alignment of colors in the direction of web travel. Also called running register.

Co-Extrusion. The process of extruding two or more films through a common die.

Color Keys®. Color proofs.

Color Matching. Blending bases to duplicate color.

Color Proof. A simulated reproduction of each of the colors due to be printed, designed to be a facsimile of the eventual printed piece.

Color Separation. Halftone films produced from color originals. These separations carry the correct dot values of cyan, magenta, and yellow for accurate color reproduction.

Colorant. Pigment or dye or a combination of the two used as the color portion of an ink.

Common Impression Cylinder Press. See central impression cylinder press.

Continuous Tone. A photographic image that contains graduated tones from black to grey. The printer reproduces these various shades of grey with varying dot percentages.

Contrast. Tonal differences between highlight, midtone, and shadow.

Cylinder. In flexography the term cylinder usually refers to those rollers on which plates are mounted (plate cylinders) and the impression roller (impression cylinder).

Densitometer. An instrument used to measure reflected or transmitted light.

Density. Opacity, or color strength.

Distorted. Intentional compensation for flexo plate elongation.

Doctor Blade. A thin blade of metal or polyethylene mounted parallel to and in contact with an anilox roll to meter excess ink from the non cell areas.

Dot Gain. Increase in the size of a halftone dot from what was on the negative to the final print. In flexography dot gain occurs during plate making and during printing.

Dryer. A tunnel or duct work to supply a drying agent to a printed ink film or coated surface. Drying agents include forced hot air and in some cases ultraviolet light waves.

Durometer. A measure of the hardness of rubber. The measuring instrument most widely used is a “Shore A” durometer gauge.

Dyes. Colored substances usually differing from pigments in their solubility in various solvents.

Elongation. Flexographic plate stretch in the around the cylinder direction.

Etch. Dissolving the non-image area of flexographic printing plates to create a relief image.

Evaporation. The transformation of a liquid to a gas. Most flexographic inks dry by evaporation.

Feathering. Fuzzy edges on printed images.

Fill-in. A reference to the printing defect caused by ink filling in reverse, fine type, and/or halftone images.

Flat Bed Scanner. An electronic halftoning device on which the originals are scanned while positioned on a flat surface, rather than a circular drum.

Font. Complete assortment of all the characters of a style and size of type.

Fountain Roll. Rubber covered roll in the two roll flexographic inking system.

The function of the fountain roll in a two roll system is to deliver and meter ink to the anilox roll.

Four Color Process. Tone reproduction method of printing yellow, magenta, cyan and black to achieve full color.

Gloss. Light reflecting capability.

Gray Balance. Printing the correct amounts of yellow, magenta and cyan needed to reproduce a neutral gray.

Gray Scale. A strip of standard gray values ranging from white to black.

Halftone. The printing method of tone reproduction whereby various shades of gray or various tonal color strengths are created by varying dot sizes, creating the illusion of continuous tone.

Halo. An undesirable outline around printed images, especially found in lower quality flexographic printing.

Heat Seal. Fusion of two surfaces through heat and pressure.

Highlight. The brightest areas of a picture, the areas with the highest reflective values.

Hue. The major attribute of color, e.g. blue, red, green . . .

Idler Roll. The undriven rolls in a web press used to support, smooth, or turn the web.

Impression. Image transfer from plate surface to substrate.

Impression Cylinder. Cylinder that provides web support during image transfer from plate to substrate.

Infeed. Refers to any nip roll or supply mechanism that supplies substrate to the printing unit section of a printing press.

In-line Press. A multi-color press where the printing units are assembled on a common plane, or in-line with one another. Also refers to any combination of printing and converting operation done simultaneously.

Intaglio. A recessed image such as that image carrier used in gravure or steel die engraving.

Journals. The shaft upon which rolls rotate, or the shaft upon which rolls are built and rotate.

Kiss Impression. The very minimum amount of pressure between anilox and plate and between plate and substrate, that will adequately transfer ink to the plate and then to the substrate.

Kraft. A type of paper made from chemically pulped wood fibers.

Kromecote. A high gloss paper finish.

Laminate. To marry or unite two or more substrates into one web.

Layout. An initial stage of design artwork, the layout is used to design size, style color, and other image element arrangements.

Letter Spacing. Adding or subtracting space between letters while typesetting copy to create a more visually pleasing letterfit or to justify a line of type.

Line Copy. Graphic image elements that are made up of solid and/or line drawings rather than continuous tone copy.

Lithography. A planographic printing form. The largest form of printing in the United States. The lithographic process selectively inks image area by “protecting” non-image area with fountain solution.

Machine Direction. The direction of paper parallel to its forward movement on a paper making machine.

Matrix. Mold for making rubber plates.

Matte Finish. Low gloss film emulsion.

Moiré. An interference in otherwise uniform tints caused by two or more dot angles being too close to one another or too close to the cell angle of the anilox.

Mottle. Uneven printed ink film, having a spotted or speckled appearance.

Negative. A tonally reversed photographic film, highlight areas of the original appear dark on a negative film, shadow areas appear light on a negative film.

Nip. Contact between two rollers.

Offset. In flexography a defect caused by an incompletely dried ink film coming in contact with another surface and transferring ink to that surface.

Opacity. The hiding quality of an ink film. The opposite of transparency.

Overprint. Trap, or one color printing over another.

Penetration. The ink films ability to absorb into the substrate.

Photopolymers. Any of a variety of materials that undergo a chemical change when exposed to ultraviolet light.

Pigment. A finely ground, dispersed colorant in ink.

Pitch Diameter. A gear or plate cylinder measurement determined by dividing the circumference by Pi.

Plate Cylinder. The cylinder in a printing press on which the printing plate (image carrier) is mounted.

Point. A unit used to measure type and especially type sizes. 72 points are equal to one inch, 12 points are equal to one pica.

Polyethylene. A clear film packaging material.

Process Color. Halftone printing, tone reproduction by printing varying dot percentages of yellow, magenta, and cyan.

Proof. A facsimile of the final printed piece, a proof can be created from plates off a proof press, from films or from electronic information.

Raster Image Processor (RIP). In computer imaging, the computerized process that results in an electronic bit map which indicates every spot position on a page in preparation for an actual print-out.

Register. Alignment of colors or printed images to each other and/or the proper position on the substrate.

Repeat. Print length of a plate cylinder in one revolution.

Reverse. Dropping type or an image out of a solid printing area.

Reverse Side Printing. Printing the underside of a clear substrate.

Screen Angles. The angle of a row or rows of halftone dots measured from a line parallel to the plate cylinder.

Screen. Tone printing, reducing the intensity of a color by printing halftone dots rather than solids.

Separations. A set of films used for platemaking. Each film carries the correct dot values for its process color yellow, magenta, cyan or black.

Serif. Fine strokes at the ends of characters in Roman lettering.

Shadow. The darkest areas of an original photograph or printed image.

Spectrophotometer. A photoelectric device used to measure the amount of spectral wavelength in a given sample.

Stack Press. A multi-color printing press where all color units are built vertically or stacked.

Stretch Factor. Mathematical formula used to calculate flexographic plate elongation.

Substrate. A web on which print or coating is applied eg. paper, polyethylene, foil.

Swatch. A sample cut from a print to be evaluated for quality characteristics.

Tension. Stress placed on a web for purposes of web and register control.

Tone. A color quality or value. A tint or shade of color. Predominate hue in a nearly neutral value.

Tone Reproduction. The re-creation of varying shades and hues of color using halftone dots and process color inks.

Tint. A means of making a given color appear lighter in value by printing it in a dot or line pattern of less than 100% coverage in any given area.

Transparent. The passage of light through a clear material.

Trapping. Printing one ink film over another.

Vignette. A printed gradual transition of color. a gray scale that gradually gets lighter and lighter in color until it fades to the same color as the sheet on which it is printed.

Viscosity. Internal resistance of a fluid to flow.

Web. A substrate used for printing including film, paper, and foil.

Web Guide. Automatic or manual device for controlling web location in a web press.

Zahn Cup. An efflux cup used to measure viscosity of a fluid.